Acoustic plasmons at the crossover between the collisionless and hydrodynamic regimes in two-dimensional electron liquids

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Hydrodynamic flow in two-dimensional electron systems has so far been probed only by dc transport [1-2] and scanning gate microscopy measurements [3]. We discuss theoretically signatures of the hydrodynamic regime in near-field optical microscopy. We analyze the dispersion of acoustic plasmon modes [4-5] in two-dimensional electron liquids using a non-local conductivity that takes into account the effects of (momentum-conserving) electron-electron collisions, (momentum-relaxing) electron-phonon and electron-impurity collisions, and many-body interactions beyond the Random Phase Approximation. We derive [6] the dispersion and, most importantly, the damping of acoustic plasmon modes and their coupling to a near-field probe, identifying key experimental signatures of the crossover between collisionless and hydrodynamic regimes.
Finally, we compare our theory with experimental data obtained from near field microscopy of graphene samples.

References

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Figures

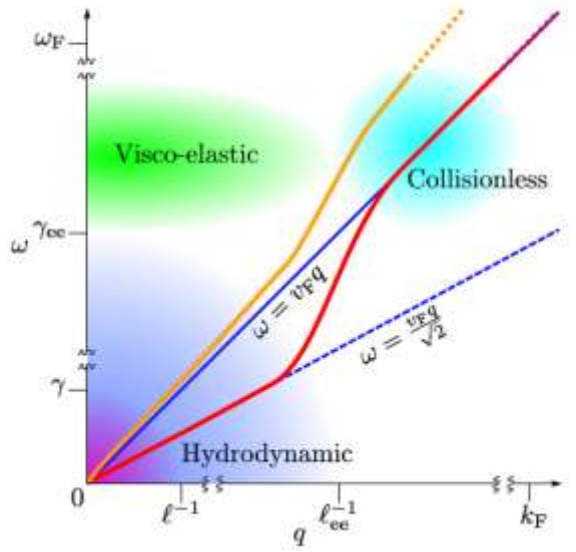

Figure 1: Sketch of the wavevector-frequency plane showing the relevant frequency and length scales for the problem at hand, and the plasmon dispersion (red and orange lines) for two different values of the screening parameter. Different regimes of linear response are highlighted.